2009. The Journal of Arachnology 37:371–372

SHORT COMMUNICATION

Presence of *Vaejovis franckei* in epiphytic bromeliads in three temperate forest types

Demetria Mondragón and **Gabriel Isaías Cruz Ruiz**: Centro Interdisciplinario de Investigación para el Desarrollo Integral Regional (CIIDIR) Unidad Oaxaca, Calle Hornos No. 1003. Santa Cruz Xoxocotlán, Oaxaca, México. E-mail: dmondragon@ipn.mx

Abstract. Reports of scorpions on epiphytic bromeliads in temperate forests are scarce. Here we present some ecological aspects of this animal-plant interaction in three different types of temperate forests (pine, pine-oak and oak forest) in Oaxaca, Mexico. From 2005 to 2007, we collected 373 bromeliads belonging to 10 species, and each plant was defoliated in search of scorpions. We found 35 individuals of *Vaejovis franckei* Sissom 1989 in 19 bromeliads: 22 specimens in *Tillandsia carlos-hankii* with 21% occupancy and an average abundance of 2.1 ± 1.9 individuals/plant; 12 specimens in *T. prodigiosa* (10% occupancy, average abundance = 1.6 ± 0.6) and one specimen in *T. calothyrsus* (3% occupancy, average abundance = 1 ± 0.0). Pine-oak forest had 29 individuals; pine forest, 4 individuals; and oak forest, 2 individuals. Percentage of occupancy differed among localities, while average abundance remained the same. *Vaejovis franckei* preferred *T. carlos-hankii* and pine-oak forest, which was correlated with the percentage of occupancy but not with the average abundance.

Keywords: Phytotelmata, Mexico

The presence of scorpions in tank-type bromeliads has been widely reported (Lucas 1975; Richardson 1999; Santos *et al.* 2006); however, most studies of scorpions on bromeliads have taken place in tropical forests, whereas research on bromeliads in temperate forests is scarce (Lucas 1975; Ochoa et al. 1993; Sissom 2000).

The present study sought to evaluate different ecological aspects of scorpions living in tank-bromeliads in three types of temperate forests. The study was carried out in Santa Catarina Ixtepeji in the state of Oaxaca, Mexico, located at 17°09′–17°11′N and 96°36′–96°39′W. Its climate varies with the altitude, and ranges from temperate to cold sub-humid with summer rains. The mean annual temperature and precipitation are 14° C and 1000 mm, respectively (INEGI 1998). Three sampling sites were selected: Peña Prieta (2870 m), a pine forest; La Petenera (2547 m), a pine-oak forest; and El Cerezal (2300 m), an oak forest. From 2005 to 2007, we sampled 373 bromeliads belonging to ten species. Bromeliads were transported to the laboratory where each plant was defoliated, and each leaf was carefully inspected. Scorpion specimens were preserved in 70% alcohol. We used the taxonomic keys of Hoffmann (1931) and Stockwell (1992) to identify the scorpions. Collected specimens have been placed in the Colección Nacional de Arácnidos in the Instituto de Biología (IB-UNAM) in Mexico City.

A total of 35 *Vaejovis franckei* Sissom 1989 was found in 19 of the 373 sampled bromeliads. We only found scorpions on *Tillandsia prodigiosa* (Lem) Baker 1889, *Tillandsia carlos-hankii* Matuda 1973 and *Tillandsia calothyrsus* Mez 1896. No specimens were found in *Viridantha plumosa* (Baker) Espejo 2002 (n = 22), *Catopsis berteroniana* (Schult. & Schult.f.) Mez 1896 (n = 17), *Tillandsia macdougallii* L.B. Smith 1949 (n = 39), *T. oaxacana* L.B. Smith 1949 (n = 50), *T. magnusiana* Wittm. 1901 (n = 10), *T. bourgaei* Baker 1887 (n = 30), or *T. violaceae Baker*, 1887 (n = 38).

The greatest number of scorpions was found in *T. carlos-hankii* (24 individuals), followed by *T. prodigiosa* (10 individuals) and *T. calothyrsus* (1 individual) (see Table 1). The percentage of occupancy differed among species ($X^2_2 = 7.60$, $P = 0.022$, $n = 167$), whereas the average abundance of scorpions per plant was the same (*T. prodigiosa* = 1.6 ± 0.6, *T. carlos-hankii* = 2.1 ± 1.9 and *T. calothyrsus* = 1.0, ANOVA, $F_{2,17} = 1.03$, $P = 0.3$).

Pine-oak forest (La Petenera) produced the greatest abundance of *V. franckei*, with 29 individuals, followed by pine forest (Peña Prieta) with 4 individuals and oak forest (El Cerezal) with 2 individuals. The percentage of occupancy differed among sampling localities (8% in Peña Prieta, 24% in Petenera and 3% in El Cerezal; $X^2_2 = 14.88$, $P = 0.006$, $n = 167$), while the average abundance of scorpions per bromeliad did not differ significantly among sites (Peña Prieta = 1.3 ± 0.6, Petenera = 2.1 ± 1.3 and Cerezal 1.0; ANOVA, $F_{8,16} = 1.1$, $P = 0.4$). The average abundance of scorpions by bromeliad ($r = 0.18$, $P = 0.9$) was not correlated with the size of the bromeliad, although the percentage of occupancy was significantly related to it (Kendall Tau = 0.154, $P = 0.018$, $n = 107$)

Most studies of arthropods living inside bromeliads do not show specificity for particular bromeliad species (Richardson 1999; Ospina-Bautista et al. 2004; Liria 2007), even though some arthropods show a strong preference for certain species of bromeliads (Quevedo & Vasconcellos-Neto 2005; Osses et al. 2007). In our case, *V. franckei* preferred *T. carlos-hankii*. This preference could be related to the architecture and/or color of the plant; e.g., *T. carlos-hankii* has green leaves with a purple base. In contrast, *T. prodigiosa* possesses green pale leaves. These differences could promote microclimatic conditions that favor the presence of scorpions, although further research is required to reach such a conclusion.

Although bromeliad size did not correlate with scorpion abundance, there may be a minimum size of bromeliad that can support scorpions, since scorpions were absent in three small species (*V. plumosa*, *T. macdougallii* and *T. magnusiana*) that do not form a water tank. Size limits the amount of water and leaf litter that accumulates inside these bromeliads, resulting in a decrease in arthropod species richness and abundance (Benzing et al. 2000), including many species that scorpions prey upon. Other studies have also shown that small bromeliads have lower abundance and species richness of arthropods that scorpions feed on, potentially resulting in lower scorpion abundances in these bromeliads (Ospina-Bautista et al. 2004; Franco 2008). Scorpions were not found in *T. oaxacana* either, probably because of the plant's small size (17–30 cm in height) and its small tank, which retains a maximum of 300 ml of water, compared to 1400 ml for *T. carlos-hankii* (Franco 2008). Bromeliad size might also directly limit the presence of scorpions, as these arthropods are relatively large, measuring up to 6 cm in length. Space within the bromeliads might thus be inadequate to provide a refuge for scorpions. Accordingly, we observed scorpions only on the larger bromeliad species (between 50 and 75 cm in height) such as *T. prodigiosa*, *T. carlos-hankii* and *T. calothyrsus*.

Table 1.—Presence of *Vaejovis franckei* Sissom 1989 on different bromeliad species in three temperate forests in Santa Catarina Ixtepeji. a = number of sample plants, b = number of plants with scorpions, c = scorpion abundance.

Bromeliad species	Pine forest			Pine-oak			Oak		
	a	b	c	a	b	c	a	b	c
Tillandsia prodigiosa (Lem) Baker, 1889	0	0	0	40	5	9	37	1	1
Tillandsia carlos-hankii Matuda, 1973	40	3	4	18	9	20	0	0	0
Tillandsia calothyrsus Mez, 1896	0	0	0	0	0	0	32	1	1

Scorpions show high specificity for certain environmental conditions (Hoffmann 1931; Lourenço & Sissom 2000; Flórez 2001; Prendini 2001). Physical conditions in the pine-oak forest site are probably the most ideal for *V. franckei*, given that it was most common in this forest type (29 individuals). The low abundance of *V. franckei* in the pine forest may explain why this scorpion was not found in *T. violaceae* in this forest type, despite the plant's suitability for the establishment of scorpions. Nonetheless, at least one other species of scorpion, *C. flavopictus*, has been found in this plant species in a cloud forest in Chiapas (Lucas 1975).

Although tank-type bromeliads appear to be a very attractive habitat for scorpions because they represent a potential source of food and refuge, in this study they colonized only a small percentage of the bromeliad specimens (9%). This result agrees with observations by Santos et al. (2006), who also reported a low percentage of occupancy (13%) for *Tityus neglectus* Mello-Leitão in four tank-type bromeliad species. Such low occupancy levels may be due to overall low scorpion densities, as reported across most types of vegetation (Bradley & Brody 1984).

ACKNOWLEDGMENTS

This project was supported by SEP-CONACYT: SEP-2004-C01-48316. We thank Megan Lore and Sheeva Sreenivasan for help with the English in this paper.

LITERATURE CITED

Benzing, D.H., H.E. Luther & B. Bennett. 2000. Relationships with fauna. Pp. 405–462. *In* Bromeliaceae: Profile of an Adaptive Radiation. (D.H. Benzing, ed.). Cambridge University Press, Cambridge, UK.

Bradley, R.A. & A.J. Brody. 1984. Relative abundance of three vaejovid scorpions across a habitat gradient. Journal of Arachnology 11:437–440.

Flórez, D.E. 2001. Escorpiones de la familia Buthidae (Chelicerata: Scorpiones) de Colombia. Biota Colombiana 2:25–30.

Franco, M.A.D. 2008. Diversidad de macroartrópodos *Tillandsia carlos-hankii* Matuda y *Tillandsia oaxacana* L. B. Smith en un bosque de pino-encino de Oaxaca. Master's Thesis, CIIDIR-OAXACA, Oaxaca, México. 101 pp.

Hoffmann, C.C. 1931. Los Scorpiones de México. Primera parte: Diplocentridae, Chactidae, Vejovidae. Annales del Instituto de Biología, México 2:291–408.

INEGI (Instituto Nacional de Estadística, Geografía e Informática). 1998. Carta del uso de suelo y vegetación. Escala 1: 250 000. Oaxaca E14-9. Carta de precipitación, escala 1: 250 000. Oaxaca E14-9.

Liria, J. 2007. Fauna fitotelmata en las bromelias *Aechmea fendleri* André y *Hohenbergia stellata* Schult del Parque Nacional San Esteban, Venezuela. Facultad de Ciencias Biológicas Universidad Nacional Mayor de San Marcos, Venezuela. Revista Peruana de Biología 14:33–38.

Lourenço, W.R. & W.D. Sissom. 2000. Scorpiones. Pp. 115–135. *In* Biodiversidad, taxonomía y biogeografía de artrópodos de México: Hacia una síntesis de su conocimiento. (J. Llorente-Bousquet, E. Gonzáles-Soriano & N. Papavero, eds.). Universidad Nacional Autónoma de México, México, D.F.

Lucas, K.E. 1975. Tank bromeliads and their macrofauna from cloud forest of Chiapas, México. M.A. Thesis, San Francisco State University, California, USA. 82 pp.

Ochoa, M.G., M.C. Lavin, F.C. Ayala & A.J. Perez. 1993. Arthropods associated with *Bromelia hemisphaerica* (Bromeliales, Bromeliaceae) in Morelos, México. Florida Entomologist 76:616–621.

Osses, F., E.G. Martins & G. Machado. 2007. Oviposition site selection by the bromeliad-dweller harvestman *Bourguyia hamata* (Arachnida: Opiliones). Journal of Ethology 26:233–241.

Ospina-Bautista, F., J.V. Estévez-Varón, J. Betacur & E. Realpe-Rebolledo. 2004. Estructura y composición de la comunidad de macro invertebrados acuáticos asociados a *Tillandsia turneri* Baker (Bromeliaceae) en un bosque Alto Andino Colombiano. Acta Zoológica Mexicana (n.s.) 20:153–166.

Prendini, L. 2001. Further additions to the scorpion fauna of Trinidad and Tobago. Journal of Arachnology 29:173–188.

Quevedo, G. & J. Vasconcellos-Neto. 2005. Spatial distribution and microhabitat preference of *Psecas chapoda* (Peckham & Peckham) (Araneae, Salticidae). Journal of Arachnology 33:124–134.

Richardson, B.A. 1999. The bromeliad microcosm and the assessment of fauna diversity on a Neotropical Forest. Biotropica 31:321–336.

Santos, R.L., E.A. de Almeida, M.G. Almeida & M.C. Serra. 2006. Biogeography of bromeliad-dwelling scorpion *Tityus neglectus* Mello-Leitão (Buthidae) in Rio Grande does Norte, Brazil. Journal of Bromeliad Society 56:201–207.

Sissom, W.D. 2000. Family Vaejovidae Thorell, 1876. Pp. 503–553. *In* Catalog of the Scorpions of the World (1758–1998). (V. Fet, W.D. Sissom, G. Lowe & M.E. Braunwalde, eds.). New York Entomological Society, New York.

Stockwell, S.A. 1992. Systematic observations on North American Scorpionida with a key and checklist of the families and genera. Journal of Medical Entomology 29:407–422.

Manuscript received 10 October 2008, revised 5 February 2009.